MSc in Computational Software Techniques in Engineering

Future Position Prediction for Pressure Refuelling Port of Commercial Aircraft

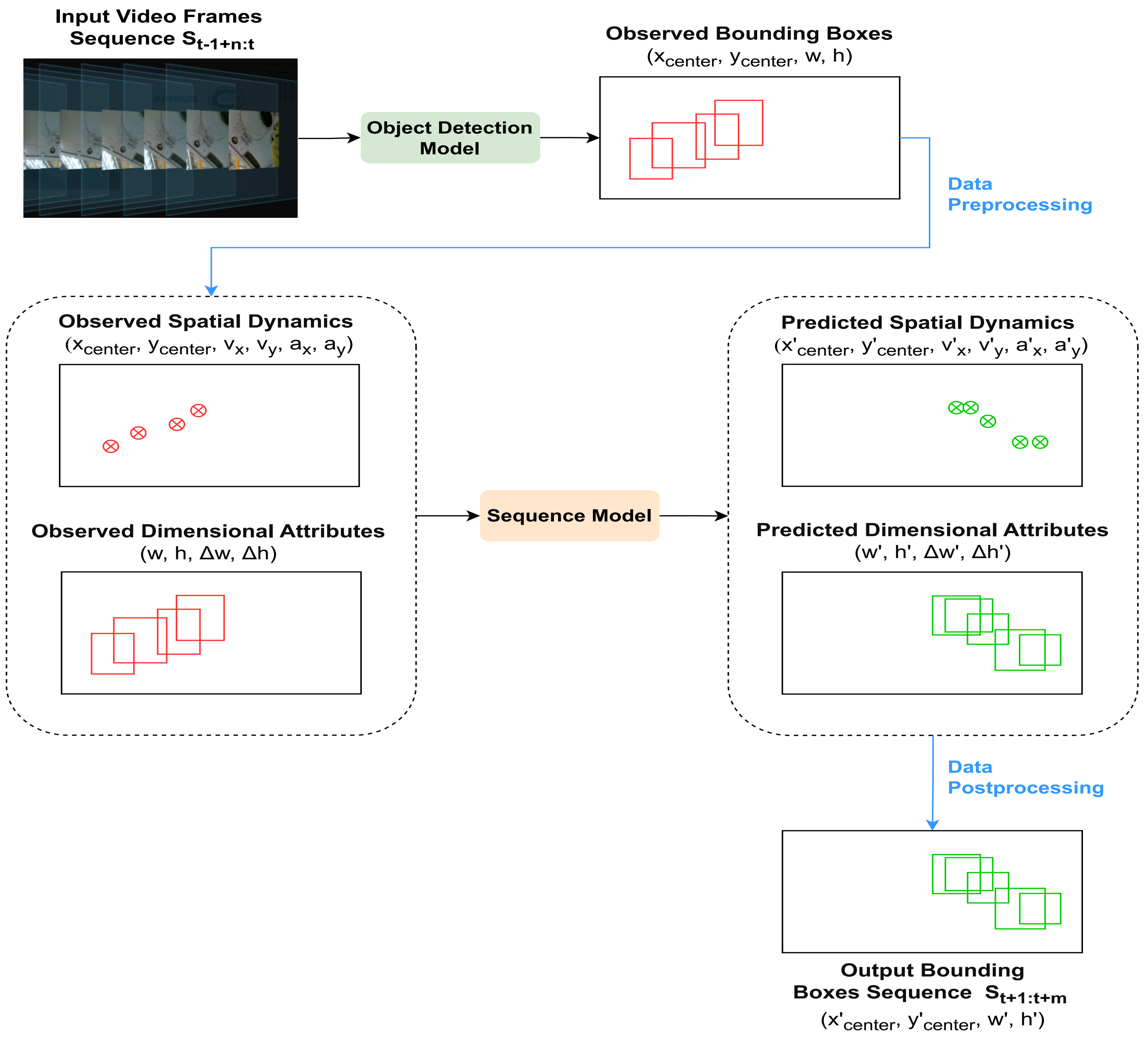
Introduction: Automating ground pressure refuelling for commercial aircraft requires precise detection and prediction of refuelling ports. Current methods face challenges with real-time accuracy and adaptability.

Goal: Develop a **framework** for predicting the **future position** of **commercial aircraft refuelling port** using advanced **Object Detection** models and **Deep Learning** to leverage the **spatial-temporal relationship** between **frames** in a **video**.

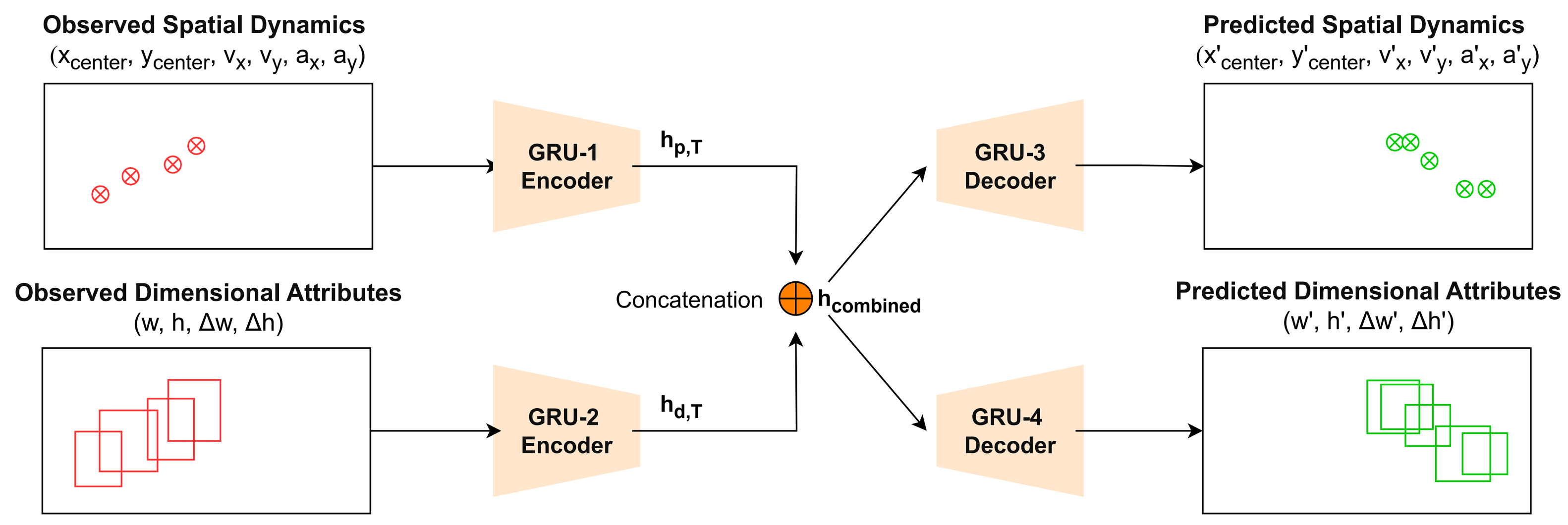
Objectives: Review state-of-the-art object detection and sequence models. Annotate and preprocess the ***Airbus A320 Refuelling Port (AARP)*** dataset. Design a framework for accurate tracking and prediction of aircraft refuelling port positions.

Contributions: Developed the ***SizPos-GRU*** model for spatial-temporal predictions. Fine-tuned ***YOLOv10*** for real-time detection. Applied advanced filtering techniques like the ***Savitzky-Golay*** and ***Kalman Filters*** to enhance prediction stability.

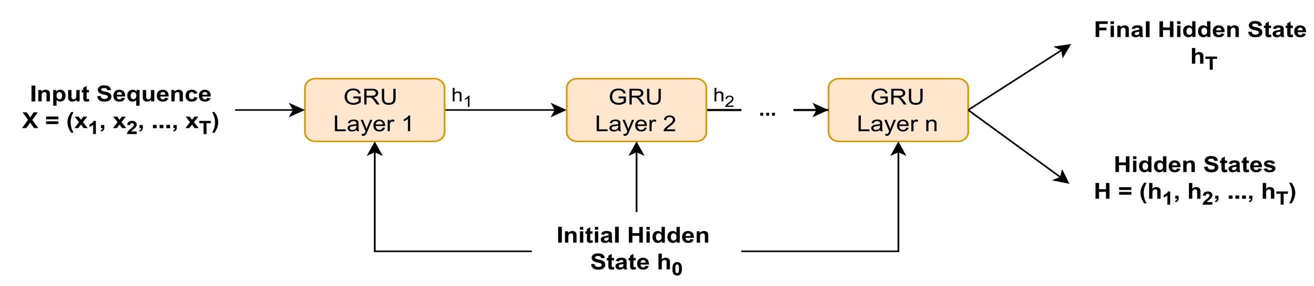
Methodology: Annotated the *AARP* dataset and trained the *SizPos-GRU* model. Integrated *YOLOv10* for detection and tested various smoothing filters. Evaluated the framework under diverse scenarios.



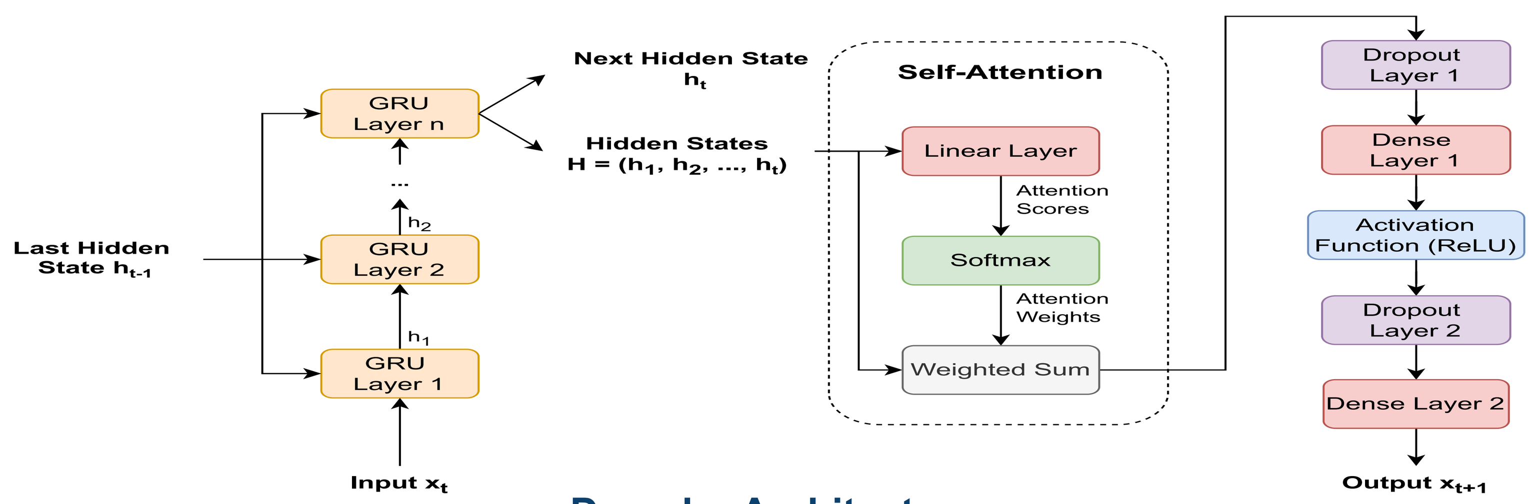
Framework Workflow



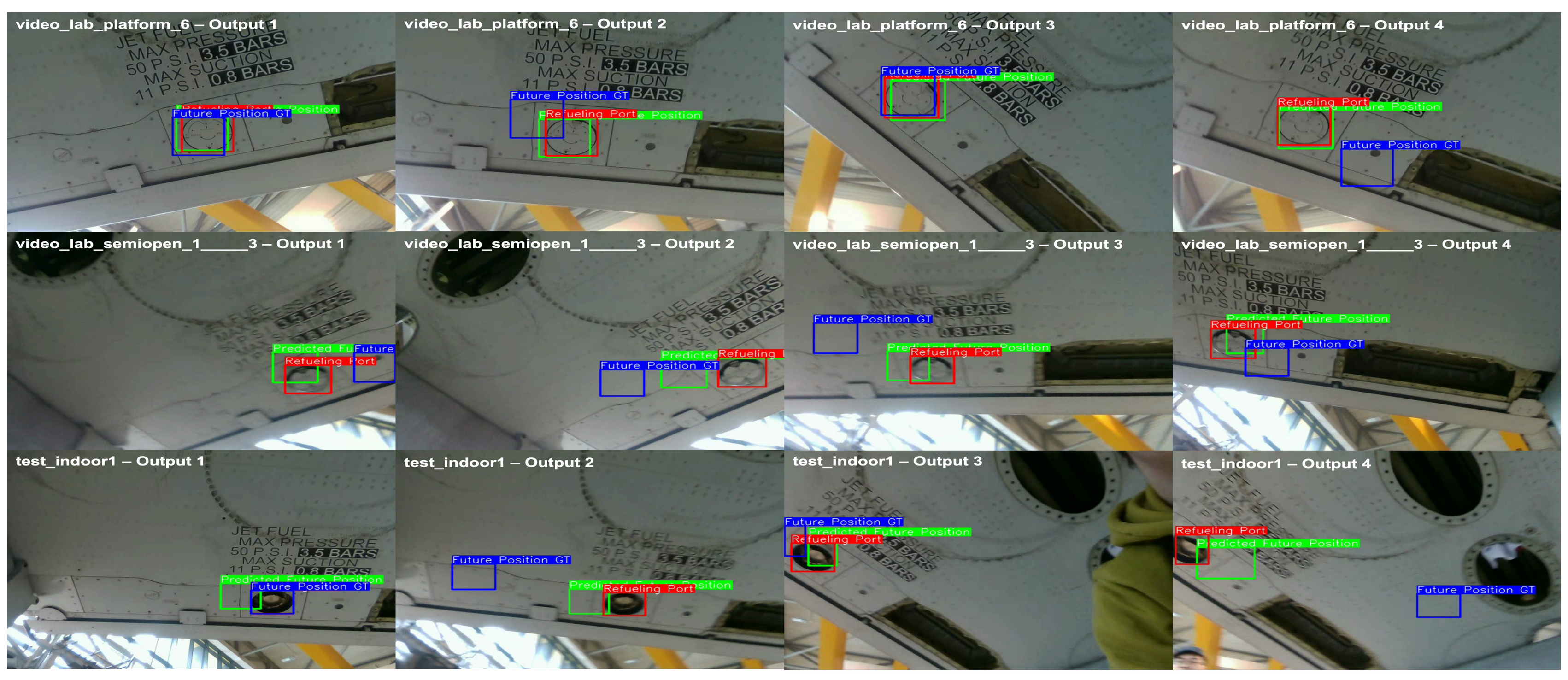
PosSiz-GRU Model Architecture



Encoder Architecture



Decoder Architecture



Visualisation of the trajectory prediction framework output. The figure shows the predicted future position in 30 frames (green), the ground truth future position in 30 frames (blue), and the current detection of the refuelling port (red).

Model	ADE (pxl)	ADE (%)	FDE (pxl)	FDE (%)	AIoU (%)	FIoU (%)
CV [65]	129.6	16.2%	268.4	33.6%	25.6	9.0
LKF [36]	110.9	13.9%	251.5	31.4%	30.1	6.4
PosVelAcc-LSTM	69.1	8.6%	115.0	14.4%	26.6	11.2
SizPos-LSTM	49.7	6.2%	95.7	12.0%	41.3	15.7
PosVelAcc-GRU	81.5	10.2%	121.3	15.2%	23.3	10.7
SizPos-GRU	**34.2**	**4.28%**	**73.4**	**9.18%**	**46.5**	**22.1**

Table 1: Performance comparison of various models on trajectory prediction tasks using 30 past frames to predict 60 future frames.

Model	ADE (pxl)	ADE (%)	FDE (pxl)	FDE (%)	AIoU (%)	FIoU (%)
CV [65]	49.9	6.2%	107.7	13.5%	45.3	20.2
LKF [36]	42.8	5.4%	97.5	12.2%	49.2	21.9
PosVelAcc-LSTM	41.8	5.2%	79.0	9.9%	42.4	20.0
SizPos-LSTM	25.3	3.2%	49.9	6.2%	58.8	36.1
PosVelAcc-GRU	39.2	4.9%	77.1	9.6%	46.3	23.1
SizPos-GRU	**17.2**	**2.15%**	**38.6**	**4.83%**	**62.4**	**39.4**

Table 2: Performance comparison of various models on trajectory prediction tasks using 15 past frames to predict 30 future frames.

Results: *SizPos-GRU* outperformed baseline models with an Average Displacement Error (ADE) of 34.2 pixels and a Final Displacement Error (FDE) of 73.4 pixels for 60-frame predictions (see Table 1). For shorter 30-frame predictions, the model achieved an ADE of 17.2 pixels and a FDE of 38.6 pixels (see Table 2).

Conclusion: The framework accurately predicts refuelling port positions, advancing aircraft refuelling automation. Future work will explore more diverse datasets and models.

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